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Social License to Operate in Mining: Present Views and Future Trends

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Abstract: The social license to operate (SLO) is an informal social contract that aims to bridge the gap among the views of the most important stakeholders involved in mining activities. The novelty of this paper lies in the fact that it discusses the current situation and the future prospects of granting a SLO, mainly at the European Union (EU) level, by considering the mine of the future, in terms of deep sea and landfill mining, and the criticality of raw materials that are required by high tech products as well as by emerging and green technologies. Also, it highlights the factors that may affect the views of all involved stakeholders, focusing on the joint efforts that are required by the industry and the society as well as on the main technological, social, political and legal issues which are relevant to the process. It is believed that if trust is developed between the involved stakeholders the SLO may prove an important tool in future mining in order to safeguard the supply of raw materials, minimize the environmental footprint and improve the quality of life in the affected regions. Finally, a conceptual flowsheet involving the main steps that may be followed for granting a SLO is proposed.

Keywords: mine of the future; landfill mining; supply of critical metals; waste management

1. Introduction

Mining impacts include among others occupation of land for mining, processing and auxiliary activities, use of large volumes of water mainly for processing of ores, development of infrastructure, disposal of waste, in some cases production of acidic leachates as well as generation of dust and noise due to blasting and traffic of heavy vehicles. All of these impacts may cause health and environmental problems to a number of recipients including humans, surrounding ecosystems and social structures [1–5]. Also, the way that environmental and social dimensions in mining interact with each other is considered very important and shows how often environmental risks and impacts end up also being risks for and impacts on societal stakeholders. This has been very clearly expressed in an excellent recent paper [6].

Often, the views about the benefits and drawbacks resulting from mining activities are contradicting. Even though in some cases local communities welcome the increased employment and income as well as the improvement of the infrastructure in mining areas, tensions may develop between local communities, companies and regional/national authorities. In order to identify all sustainability hotspots and prevent or mitigate such tensions, mining companies implement corporate social responsibility (CSR) strategies aiming at minimizing their production footprint in order to improve interactions and relationships with local communities. The CSR is a general framework that aims to map and assess the performance of a mining company by taking into account societal, environmental and economic issues [7–11].

On the other hand, the social license to operate (SLO) is only considered as an informal social contract, which does not have the form of a legal agreement. The concept of SLO was first developed in the late 1990s, when the mining industry failed to meet societal and community expectations [12–14], but it can easily be applied in any other industrial sector [15]. SLO is also based on the principles of the Global Mining Initiative, which was developed in 1998 by major mining and metals companies and aimed to advance the industry's role in the transition to sustainable development [16]. Since then the concept of a SLO has been widely accepted by the industry as an essential tool of success and has prompted companies to look well beyond their self-interest [17]. SLO aims to bridge the gap among the views of the most important stakeholders involved in mining activities and in particular to take into account the views of the general public, even from the design phase of a project, before any important decision is taken. The existence of a SLO means that the project has sufficient social approval, which is a prerequisite for its sustainability in the long term [18,19].

Most studies on mining SLOs were carried out outside Europe, mainly in developing countries of Latin America, Africa and Asia. However, it is interesting to mention that most of the researchers were from Western institutions. Various approaches were used to assess socio-economic and environmental aspects as well as citizens' perceptions pertinent to mining projects in different cultural settings and the outcomes varied widely [20]. Jartti et al. [21] recently carried out a national survey and tested a theoretical model to determine the factors affecting mining SLOs in Finland. Their results were similar to those derived from earlier studies and indicated that several factors were decisive in obtaining and maintaining a SLO [22,23].

In the mining sector, the concept of SLO was first developed as a result of the criticism to mining projects and as a mechanism to ensure sustainable mining, environmental protection, cooperation with the local communities, preservation of the quality of life in the affected regions and finally the viability of the mining sector [24]. The SLO may be considered as an integral part of the CSR and can only be granted when trust has been developed between the mining company and all local major stakeholders [25,26]. On the other hand, it is known that there are several economic, social, political and environmental factors that affect the views of all involved stakeholders, while it is also widely accepted that these views may be different in different regions of the same country or in different countries. It is also known that these views may also change after a short period of time, if for example the economic conditions in a region, country or at the international level change, or even during or after periods of pandemic, as we face today with COVID-19. The familiarity of a region with mining activities as well as the impacts caused by previous mining projects in a specific region of a country are also important decisive factors [27]. Gender issues may be also considered, since men and women judge mining operations from different perspectives [28]. The methodology that needs to be followed for granting a SLO is usually complex and often requires different approaches, the identification of social, legal and political risks as well as the use of surveys and different models [29,30].

Regarding artisanal and small-scale mining, which mainly occurs in several third world countries, the situation may be very different from country to country. It is known that it offers some socioeconomic benefits but environmental problems, which depend on the mining method and the scale of operation, may often be devastating [31,32]. In some countries, such as Ghana, artisanal and small scale mining has been recently banned and this decision has caused social unrest. Also in this case, a kind of SLO is required but the involvement of local governments is crucial in order to implement its basic principles. Apart from this, a number of reforms including education and training, adoption of improved technologies, increased participation of local stakeholders in decision making and new legislation is required in order to ensure socio-environmental sustainability [33].

In economic terms, the performance of a mining project can be assessed by three indicators, namely the value of production, the value added and the level of employment. It is widely accepted that the level of employment is closely related to social aspects in a mining region. The overall impact of a mining industry can be assessed after a detailed analysis and deeper understanding of other indicators including water consumption, emissions, productivity, profit, tax payments, land use, communication, transparency and community involvement. All of these factors are strongly related to the SLO, and may exhibit reflections at the national level, especially if the industrial performance in social and environmental issues is poor. It is also probable that local people may have a more positive view for exploration and mining activities compared to the general nationwide public.

Figure 1 shows the main stakeholders involved in the process of acquiring a SLO as well as the main anticipated benefits for each one of them. It is seen from this figure that the SLO may result in noticeable benefits for all interested parties and especially for the mining company, involving smooth operation, CSR and triple bottom line aspirations [25] as well as the local community with direct social, economic and environmental benefits. The main benefits for the governments include the ability to act on policies and take decisions, while the wider public may also have multiple indirect benefits.

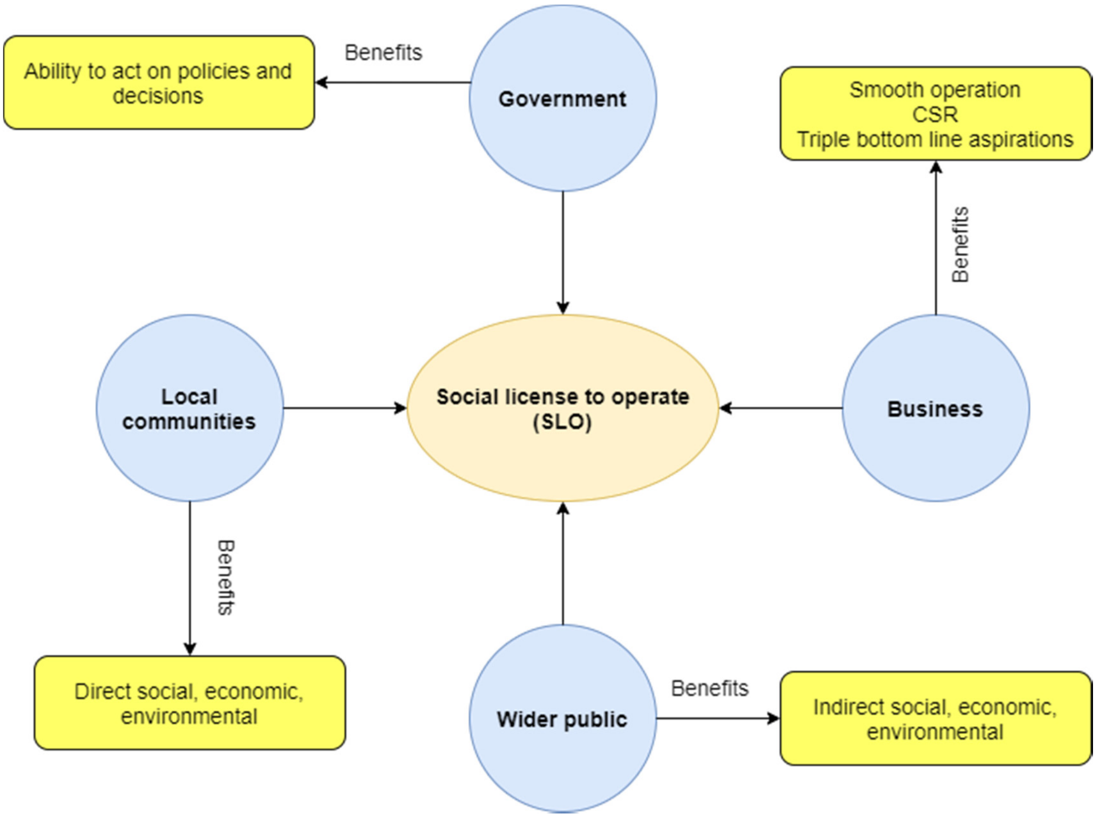

Figure 1. The main stakeholders involved in acquiring a social license to operate (SLO) and their main benefits.

The present study aims to provide thoughts and facts about the present situation as well as the future perception of SLO, by considering the future criticality of raw materials and that the mine of the future will be very different from the mine of today. It also highlights the main technological, social, political and legal issues that may affect the future views of all involved stakeholders.

2. Criticality of Raw Materials at the EU Level

Critical metals are necessary for almost all emerging technologies in various sectors including transport electrification and renewable energy, thus their supply remains unaffected by technological barriers and trade limitations. Future activities and policies should focus on extraction of critical metals from "difficult to mine resources", secondary materials and wastes, while end-of-life recycling needs to be intensified [34,35].

Electrification of transport is a very important objective at the world level in order to reduce greenhouse gas (GHG) emissions. It is estimated that the number of electric vehicles (EVs), provided that several environmental and resource burdens are overcome, will be over 2.5 billion in 2050 [36,37]. The EVs of the future will have electronic components fabricated from several critical and light metals, such as Co, Ni, Li, Al and Mg, as well as rare earth elements (REEs) such as Nd and Dy. The supply risk of these metals depends among others on market concentration, thus recycling and substitution will be required to reduce this vulnerability [38]. It is well known that switching from oil, gas and coal to solar cells, wind turbines, fuel cells, and batteries can reduce carbon emissions [39,40]. It is also known that clean energy technologies are material intensive and depend on several critical and platinum group metals (PGMs), as well as REEs [41].

The two main parameters that are used to determine the criticality of a material, at least at the EU level are economic importance (EI) and supply risk (SR) [42]. The economic importance (EI), Equation (1), aims at assessing the importance of a material for the EU economy by taking into account the end-use applications and the value added (VA) of pertinent sectors at the NACE Rev.2 (2-digit level) [43]. The term NACE derives from the French Nomenclature statistique des Activités économiques dans la Communauté Européenne (European Classification of Economic Activities in the European Community). The economic importance may be corrected by the substitution index (SI_{EI}), which is related to technical and cost performance of the substitutes for specific applications.

$$EI = \sum_{S} (A_S * Q_S) * SI_{EI} \tag{1}$$

where: *EI*: economic importance; A_S: the share of end use of a raw material in a NACE Rev. 2 (2-digit level) sector; Q_S: the sector's VA at the NACE Rev. 2 (2-digit level); SI_{EI}: the substitution index of a raw material related to economic importance; *s:* specific sector.

Supply risk (SR) indicates the risk of a disruption in the EU supply for a specific material. It takes into account the concentration of its primary supply from producing countries, as well as governance efficiency and trade issues. The highest SR is determined at the 'bottleneck' stage of a material, by considering extraction or processing. The major risk-reducing measures include substitution and recycling [44].

Another important indicator for the EU is import reliance (IR), which takes into account the domestic production as well as imports and exports from and to non-EU countries. Thus, for the calculation of IR two sets of countries are considered, global suppliers and countries from which the EU is sourcing the raw materials.

The import reliance (IR) of a material can be calculated by using the following (Equation (2)), in which the numerator denotes net imports while the denominator the apparent consumption

$$Import\ Reliance\ (IR) = \frac{Import - Export}{Domestic\ Production + Import - Export}. \tag{2}$$

Due to the lack of acceptable data for secondary raw materials production and trade, the supply of secondary raw materials is represented by the recycling parameter 'end-of-life recycling input rate' (EOL_{RIR}). EOL_{RIR} is used as a risk reducing factor for primary supply. It is mentioned that no correction is applied for the supply risk of secondary raw materials.

The EOL_{RIR} denotes the ratio of recycling (e.g., from scrap) to meet the European demand of a candidate raw material, which is equal to primary and secondary material inputs, and is expressed by (Equation (3))

$$EOL_{RIR} = \frac{Import\ of\ secondary\ material\ to\ EU\ [from\ old\ scrap]}{Import\ of\ primary\ material\ to\ EU + Import\ of\ secondary\ material\ to\ EU}. \tag{3}$$

Another parameter, namely the trade parameter '*t*' can be used to assess the trade contribution in order to manage the supply risk of a candidate raw material for a specific country. It is important to mention that the impact of potential export restrictions and existing trade agreements between the EU and non-EU countries should always be taken into account.

The use of the previously mentioned formulas for the calculation of all important indicators that assess the criticality of a specific raw material should be always based on reliable and published data of high quality, otherwise misleading conclusions may be drawn.

The criticality of a raw material is a parameter that should be frequently assessed, e.g., every 2–3 or a maximum of 5 years. Special care should be taken during data interpretation since countries often declare inaccurate or non-uniform data, especially when a raw material is produced, exported or imported in different forms. Other important aspects that should be taken into account in the future are the consideration of socioeconomic factors and the assessment of metal criticality in life cycle assessment (LCA) studies [45].

3. Mine of the Future

It is anticipated that the demand for certain metals will increase in the future due to the rising world population and economic growth, as well as the development of new technologies in the frame of green and circular economy. It is also expected that securing long-term access to geological deposits in each region will be a decisive factor for the future resilience of the industry. The mine of the future is anticipated to meet the demand for the supply of critical raw materials (CRM) which are of high importance to the economy, but their supply is associated with high risk. This may alleviate the relative security of supplies at the regional and global levels and thus ease the political and market situation for many raw materials. In addition, it will allow value chains to develop, ensuring that strategically important and high-tech industries will maintain their productivity [46].

In the coming years it is believed that more metals will be produced from deep-sea and urban mining. The primary mine of the future is anticipated to exploit mineral raw materials at greater depth than today, as a result of declining ore grades, and will require entirely different approaches compared to today's deep mines. Most activities, including waste management, will be carried out underground, thus lesser material volumes will be transported to the surface and fewer above ground installations will be required. It is believed that the mine of the future will be more eco-efficient and its environmental impact will be much smaller. Regarding assessment of environmental impacts, techniques such as geographical information systems (GIS) and remote sensing will be further exploited and applied [47]. The ideal mine of the future will be invisible, safer and will have almost zero-impact and environmental footprint.

Currently there is no mining of minerals from deep-sea international waters, while mining projects are at a similar state as they already were at the end of the 70s [48]. However, this activity is anticipated to be intensified in the future for the mining of various deposits including manganese and polymetallic nodules, cobalt-rich crusts and seafloor-massive sulfides. Deep sea mining, if successfully carried out, will ensure security of supply and fill the gap in the market where either recycling is not possible or adequate, or the burden on terrestrial mines is too great.

It is known that each year millions of tons of valuable metals are lost in many countries as a result of landfilling [49]. So, in several regions efforts are made and policy measures are taken to increase the recovery of metals contained in various waste streams. Urban mining and circular economy are receiving particular attention in the European Union, as underlined at the annual Raw Materials Week in Brussels [50–52]. Recently, the Urban Mine Platform was launched in order to build a centralized database of information on stocks, flows and treatment of waste electrical and electronic equipment (WEEE), end-of-life vehicles, batteries and mining wastes [53].

It is also anticipated that in the future the extraction of high-tech metals, including rare earth elements (REEs), which are necessary for strategic industries and the development of modern technologies, especially for green energy, will be intensified [54,55]. Wind turbines, fluorescence lamps, smartphones, electric vehicles (EVs), Li-ion batteries and computers will be the main sources of secondary high-tech metals. Regarding REEs, there are many challenges associated with their extraction and processing and thus their global availability. These include (i) their geological distribution, as it is known that REE-containing minerals rarely occur in concentrated forms, thus making their exploitation difficult and (ii) their presence with uranium or thorium decay chains, which makes their processing more challenging and expensive [56–58]. As a result, urban mining will be a pillar of the circular economy in the near future and is anticipated to have strong economic (generating profit through the development and application of innovative technologies), and environmental (reducing environmental impacts) benefits [59].

While deep-sea mining should meet the standards of the United Nations Convention on the Law of the Sea [60] in order to safeguard this heritage of mankind, protect the marine environment, and prevent adverse impacts to marine flora and fauna, its social acceptance and the acquisition of a SLO may depend on the outcome of an independent cost-benefit analysis and continuous monitoring of activities [61]. By taking into account that knowledge gaps exist while environmental management standards and guidelines for deep-sea mining are in their infancy, a reliable, carefully designed and effective environmental management plan, based on the experience of the offshore oil and gas industry as well as the developed regulations by the International Seabed Authority (ISA), is required [62,63]. So far, the risk from plumes generated during mining activities to benthic pelagic habitats cannot be assessed with a high degree of reliability because the vulnerability certainly differs for pelagic habitats and different types of plumes [64,65]. Prior to any decisions taken, the benefits should be understood, while the drawbacks and impacts associated with this type of mining should be clearly defined [66–69].

In order to achieve its goals, the mine of the future will require advanced integrated exploration and extraction technologies as well as rock mechanics and ground control issues. Today, it is believed that the development of the mine of the future is feasible but the Technology Readiness Level (TRL) of the involved technologies needs to be substantially improved [70].

Thus, the mine of the future will be associated with different environmental, economic and social issues. By considering that the societal needs and priorities may change in the frame of a more global society, the attitude of the stakeholders may also change. If we assume that the future mine will be more "invisible" and the environmental laws will become more stringent, it is possible that the community granting of the SLO may become more easy. In addition, by taking into account that many countries or regions may become more conservative in the near future, as a result of emerging issues such as the migration of refugees or the COVID-19 outbreak, which will impose restrictions pertinent to free transport of goods and people and thus affect the sufficiency of raw materials to meet industrial demand, granting of the SLO to mining projects may become easier. Thus, the future situation for granting a SLO is difficult to predict, while geopolitical changes should be closely monitored.

Figure 2 shows the requirements and the anticipated advantages from the operation of the mine of the future as well as all social, environmental and legal issues that need to be taken into account during the process of granting a SLO. These requirements and advantages mainly refer to liberal societies and definitely differ in countries governed by other regimes or when tensions exist and the perception of mining is different [71,72]. Important aspects for the requirements are among others, the knowledge-driven industry, the implementation of automated and remote controlled operations and the availability of skilled labor, while lower energy requirements, a smaller environmental footprint, higher safety, productivity and a contribution to circular economy are some of the most important advantages [73–75].

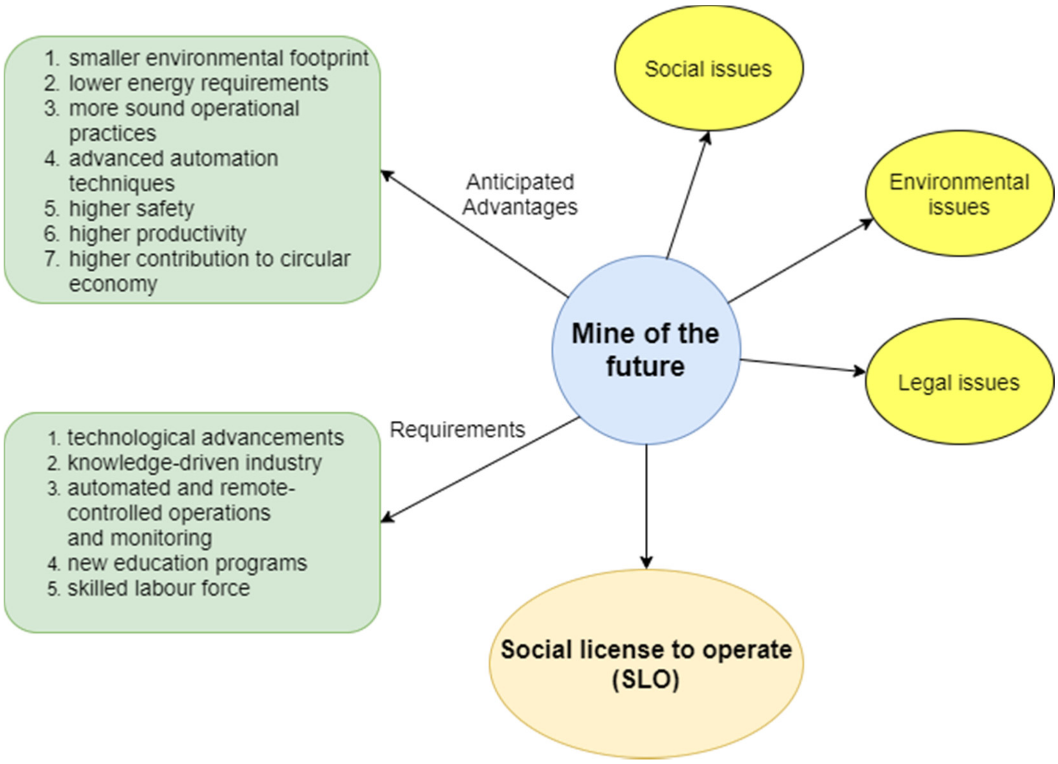

Figure 2. Requirements and anticipated advantages as a result of an existing SLO for the mine of the future.

4. European Dimension of Social License to Operate in Mining

Europe has many resources and mines many different metals and minerals, as well as ornamental stones, sand, gravel and aggregates. However, the situation in terms of mining and metal extraction varies widely by geography.

It is known that while mining in the rest of the world has increased exponentially, it has remained limited in Europe for a number of reasons, including avoidance of environmental impacts and opposition from several stakeholders, as well as cheap imports of raw materials from non-EU countries. This means that the EU now accounts for a smaller share of global mining than it did some decades ago. This situation seems to have changed the in last years, mainly regarding exploration and mapping of resources as well as the anticipated transition towards a resource efficient circular economy [76,77]. In addition, metal recovery from secondary resources gains importance at EU level in the last years [75]. On the other hand, EU industries are at the forefront of innovation in raw-materials supply and are characterized by high efficiency [78]. In the last 20 years (the 2002–2019 period) the EU has had a strong trade deficit and has been a net importer of raw materials, with the last's year trade deficit at €31 billion [79]. There are several reasons for this situation and the most important, not necessarily in descending order, are: exhaustion of known deposits, limited exploration activities for new deposits, declining grades of existing deposits, development of new mines in other parts of the world, high labor and infrastructure costs, strict legislation and the long period required to obtain mining permits, aggressive industrial and economic policies, exposure to international competition operating at lower standards and the general attitude of most Europeans against mining.

Figure 3 shows the most important factors that affect the trade deficit of raw materials in the EU. These include among others declining ore grades, limited exploration for new deposits, international competition, strict legislation and the general attitude of most Europeans against mining. These factors prove that until now it was less expensive, much faster and 'socially neutral' to import the resources than to mine them domestically. Another issue that needs to be stressed is that most critical raw materials imported in Europe originate from countries lacking political and economic stability. Indeed, over 50% of major reserves are located in countries with a per capita gross national income of $10 per day or less [80].

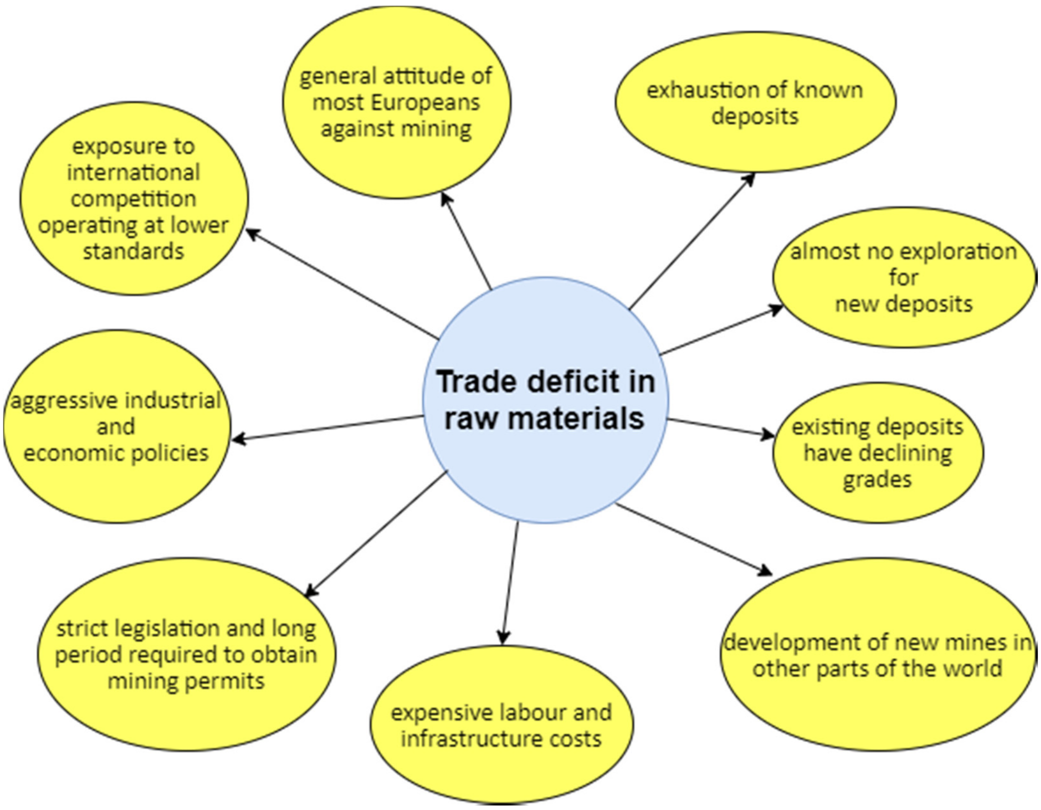

Figure 3. Factors affecting trade deficit of raw materials in the EU.

Also, the adoption of EU waste legislation with increased recycling targets for overall municipal waste, and specific targets for packaging waste—80% for ferrous metals and 60% for aluminium—will contribute to the increased recovery of metals [81]. It is believed that this legislation will encourage better product design and set standards that will improve circularity, extend producer responsibility, improve collection rates and change consumer behavior, thereby contributing to an easier granting of a SLO at least at the European level.

As EU policymakers search for ways to secure sourcing of raw materials, they have access to various tools in their toolbox. Expanding domestic mining activity may be one of the routes to greater security. Other aspects that need to be considered include (i) many citizen groups in Europe blame the European mining industry for the environmental impacts caused from mining activities and improper waste management [82], and (ii) several European industrial sectors are worried about the uncertainty and the supply risk for several critical metals, factors which may affect the profitability of the industry and the security of the jobs. Also, it has to be underlined that the continuous decline of the mining sector will definitely lead to a loss of expertise in the sector as well as to the higher risk of loss of investment on research and education since young and well educated scientists may move to other regions. In order to mitigate these impacts, the European Union has invested heavily in research and innovation activities through the Framework Programme Horizon 2020, for the period 2014 to 2020, and plans to continue investments in Horizon Europe, for the period 2021–2027. All of these factors may be considered in the future regarding investments in extractive industries and may affect the attitude for granting a SLO at European level.

5. Proposed Methodological Approach for the Future

Figure 4 provides an indicative flowsheet that may be followed in the future for granting a SLO in the mining sector. First, the goal and scope of the mining project needs to be clearly defined. This should include the type of the project, the type of the ore excavated from the surface, underground, deep sea mine or landfill, the mining method, the data requirements and the major risks involved from the exploration to the cease of activities phases [83]. Then, the availability and quality of data needs to be carefully examined. Based on these aspects, the most important indicators need to be carefully selected. At a later stage, when additional data is evaluated, other indicators may be added (or excluded).

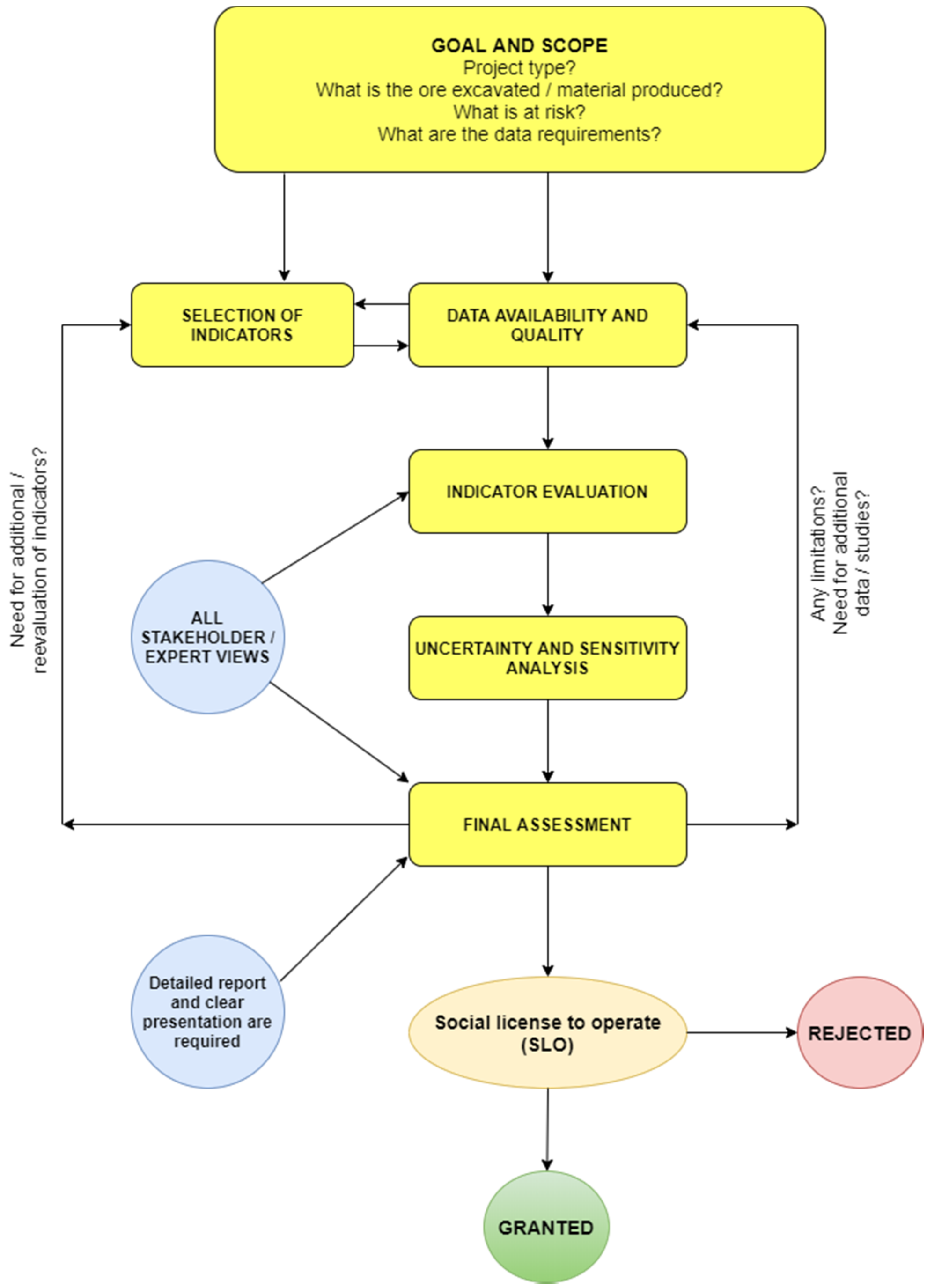

Figure 4. Flowsheet of activities that need to be followed for granting a SLO.

The final assessment should include evaluation of all indicators, consideration of all stakeholder and expert views as well as carrying out an uncertainty and sensitivity analysis. The results of the assessment should be made public in the form of a detailed report while presentations may also be delivered to the local communities and regional authorities. Benefits and impacts to all involved stakeholders should be clearly underlined and risk mitigation measures should be agreed for any emergent risk for the entire duration of the project.

In addition, good practices from other similar projects and regions need to be indicated and on this basis risks and results should be compared. It is also very useful if the anticipated impacts for the most important impact categories are verified by the implementation of a LCA study, which should also include social impacts. By taking into account the views of all involved parties, limitations will be identified and the need for any additional data or studies will be assessed. It is underlined that the entire process should be carefully planned, widely disseminated and include a clear roadmap so that it is completed within a reasonable time frame. Long procedures, complicated and often contradicting legislation usually prevents the mining sector from investing in new projects and may create tensions between the company and the public. It is believed that if all of these steps are followed with the required clarity, the right decision will be reached relatively quickly, and the SLO will be granted or rejected. In addition, this flowsheet may be also used as a tool to address significant problems and issues pertinent to the implementation of a mining project as well as an indicator of deficiencies in the existing institutional framework, as proposed by a recent study carried out in Sweden [84].

Finally, an issue that needs to be stressed is the role of mining professionals as well as entrepreneurs, who will be important stakeholders in the mine of the future and their role in granting a SLO will be crucial. Collaboration, communication and education in entrepreneurial issues in mining regions are considered important steps towards establishing trust between all involved parties. Mining typically has positive employment and entrepreneurial impacts, but the magnitude of these impacts differs, depending on the geographical region. In addition, local entrepreneurs may have significant benefits since they form the base for the provision of non-mining and non-agricultural related services and goods to the wider mining community [85,86]. The Southern African Institute of Mining and Metallurgy (SAIMM) Young Professionals Council (YPC) has recognized that there is a need for young entrepreneurs, professionals considering the entrepreneurial route and businesses to share ideas and insights into the metals industry in a professional and engaging environment and has organized in 2019 a conference to promote all these issues [87]. Thus, entrepreneurial activities are considered as an important driving force for facilitating economic growth and sustainable development in mining regions and may contribute to obtaining and maintaining a SLO.

6. Conclusions

This paper presents the basic methodology to assess the criticality of raw materials, discusses the main factors that affect the current trade deficit of raw materials in the EU and highlights the main advantages of a SLO at the European level.

Important aspects that need to be seriously taken into account in the process of obtaining a SLO for a mining project in the future include (i) the fragile world economy, as was recently confirmed by the COVID-19 outbreak, which may result in problems pertinent to the supply of critical raw materials that are used in various emerging and green technologies, including transport electrification and renewable energy, (ii) the increased future demand for certain metals, including REEs, due to the rising world population and economic growth and (iii) the fact that the mine of the future, which will involve deep sea and landfill mining, will be entirely different from the mine of today in all crucial aspects, such as exploration, mining, processing and waste management.

The proposed flowsheet for granting a SLO for a mining project takes into account all socio-economic and environmental aspects as well as citizens' perceptions and aims to overcome existing problems due to different cultures and attitudes towards mining in each country. In addition, this flowsheet may be also used as a tool to reduce the environmental footprint, address significant problems and issues pertinent to the implementation of a mining project as well as an indicator of deficiencies and gaps in the existing institutional framework.

Finally, an issue that is considered crucial for the future of SLO in mining is the role of mining professionals and entrepreneurs, who in close cooperation with all other major stakeholders may change the general social perception of mining and properly apply the principles of a green and circular economy.

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